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The Value of Pediatric Appendicitis Score and Laboratory Findings on the Diagnosis of Pediatric Appendicitis

Çocuk Apandisitlerinin Tanısında Pediatrik Apandisit Skoru ve Laboratuvar Bulgularının Değeri

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ABSTRACT

Objective: Pediatric appendicitis score (PAS) is a scoring system which is improved to simplify the diagnosis of appendicitis in children. In this article it is aimed to investigate the efficiency of PAS and additional laboratory data in diagnosing appendicitis.

Material and Methods: Between 1st January 2010 and 31st December 2010, patients admitted to our department that are followed up and treated with an initial diagnosis of acute abdomen were reviewed retrospectively. Patients which were operated and histopathological examination confirmed the diagnosis appendicitis is defined as 1st group, and the patients with negative exploration and the ones that are non-operated are defined as 2nd group. Groups are compared in terms of demographic data, hospitalization time, PAS and laboratory data.

Results: A total of 562 patients (321 male, 241 female) with an initial diagnosis of acute abdomen are admitted to our department in the one-year period. There were 350 patients (224 acute, 126 complicated appendicitis) in the 1st group, and 212 patients (31 negative exploration, 181 follow-up) in the 2nd group. While the preoperative hospitalization time between the acute and complicated cases did not have significant difference ($p>0.05$), complicated cases had a long postoperative hospitalization time ($p<0.001$). PAS had significant difference between the acute, complicated and negative explorations ($p<0.001$). PAS was increased proportional to the severity of the appendicitis ($p<0.001$). White blood cell count, neutrophile count, neutrophile percentage, neutrophile/lymphocyte (N/L) ratio, and C-reactive protein (CRP) rates were significantly higher in the appendicitis group ($p<0.001$). Fever (in the 1st group 29.1%) and the migration of pain to right-lower quadrant (in the 1st group 6.2%) that are the PAS components had at least contribution to the scoring. Instead, the usage of N/L (81% higher in the 1st group) and CRP (76% higher in the 1st group) values increases the sensitivity of the score from 88.6% to 91.1% in diagnosing appendicitis.

Conclusion: Addition of the N/L ratio and CRP values may increase the diagnostic ability of the PAS which is composed of clinical and laboratory indications.

Key Words: Appendicitis, Blood cell count, Child, C-reactive protein, Physical examination

ÖZET

Amaç: Pediatrik apandisit skoru (PAS) çocuklarda akut apandisit tanısı koymayı kolaylaştırmak amacıyla geliştirilen bir skorlama sistemidir. Bu çalışmada, PAS ve ek laboratuvar verilerinin apandisit tanısı koymadaki etkinliklerinin araştırılması amaçlanmıştır.

Gereç ve Yöntemler: 1 Ocak 2010–31 Aralık 2010 tarihleri arasında kliniğimize akut batın ön tanısıyla yatırılarak takip ve tedavi edilen hastalar geriye dönük olarak değerlendirildi. Bu hastalardan opere edilip, patoloji sonucuyla apandisit tanısı doğrulananlar 1. grup, opere edilip negatif çıkan ve opere edilmeyen hastalar 2. grup olarak isimlendirildi. Gruplar demografik verileri, yatış süreleri, PAS ve laboratuvar bulguları açısından karşılaştırıldı.

Bulgular: Bir yıllık süre içerisinde kliniğimize akut batın ön tanısıyla 562 hasta (321 erkek, 241 kız) yatırıldı. 1. grupta 350 hasta (224 akut, 126 komplike apandisit), 2. grupta 212 hasta (31 negatif apendektomi, 181 gözlem) vardı. Preoperatif yatış süreleri açısından akut ve komplike olgular arasında anlamlı fark yokken ($p>0,05$), postoperatif yatış süreleri komplike olgularda daha uzundu ($p<0,001$). PAS açısından akut, komplike ve negatif olan hastalar arasında anlamlı fark bulundu ($p<0,001$). PAS skorunun apandisit şiddeti ile orantılı olarak arttığı görüldü ($p<0,001$). Lökosit sayısı, nötrofil

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sayısı, nötrofil yüzdesi, nötrofil/lenfosit oranı (N/L) ve C-reaktif protein (CRP) değerlerinin apandisit olan grupta belirgin yüksek olduğu görüldü (p<0,001). PAS bileşenlerinden ateş (1.grupta % 29.1) ve ağrının sağ alt kadrana migrasyonunun (1. grupta %6.2) tanıya en az katkı sağladığı saptandı. Bunlar yerine N/L (1. grubun %81'inde yüksek) ve CRP (1. grubun %76'sında yüksek) değerlerinin kullanılmasıyla, skorun apandisit tanısı koydurmadaki duyarlılığının %88.6'dan, %91.1'e çıktığı bulundu.

Sonuç: Klinik ve laboratuvar bulgularına dayanılarak hazırlanmış olan PAS'da, N/L oranı ve CRP değerlerinin de kullanılmasıyla, tanı koyduruculuğunun daha da artacağı düşüncesindeyiz.

Anahtar Sözcükler: Apandisit, Kan sayımı, Çocuk, C-reaktif protein, Fizik muayene

INTRODUCTION

Abdominal pain is one of the most common complaint in pediatric age group, and the most urgent problem necessitating abdominal surgery in childhood (1,2). "Appendicitis" was first defined by Reginald Fitz in 1886. Over the years, to diagnose the appendicitis, beside the history and physical examination of the patient, laboratory tests including leukocyte count, neutrophil ratio, and CRP together with imaging techniques such as ultrasonography have been used, but there is not any completely (100%) reliable sign, evidence or laboratory test for the diagnosis of appendicitis (3-5). Diagnosing appendicitis is more difficult in children than the adults. Consequently, in the recent years various appendicitis scores have been used to support or differentiate the true diagnosis of appendicitis (1-3,6). The first simple scoring system was defined by Alvarado in 1986, and subsequently modified by Kalan et al. Although these scoring systems were more useful for adults, with various modifications the scoring systems have been adapted to the children (1,5). Many authors support the use of pediatric appendicitis score (PAS); to use the time and resources of the emergency service properly, to reduce health care expenditures, to prevent negative surgical explorations or radiation exposure caused by computed tomography used for diagnosis (1-3,5,6). In this study, we aimed to investigate the efficiency of PAS and additional laboratory parameters for diagnosing appendicitis.

MATERIALS and METHODS

Between 1st January 2010 and 31st December 2010, patients admitted to our pediatric surgery department that were followed up and treated with an initial diagnosis of acute abdomen were reviewed retrospectively after the local ethic committee approval was obtained. Patients which were operated and histopathological examinations confirmed the diagnosis of appendicitis was defined as 1st group (Appendicitis Group), and the patients with negative exploration and the ones who were hospitalized and followed up for the abdominal pain and discharged without surgical exploration were defined as 2nd group (Other Group). The patients who were operated apart from appendicitis were excluded from the study. Groups were compared in terms of demographic data, duration of hospitalization, PAS values and laboratory data. The components of the pediatric appendicitis score (PAS); anorexia, nausea-vomiting, migration of the pain to the right lower quadrant, percussion tenderness, fever, leukocytosis, polymorphonuclear neutrophilia were evaluated. Concordant with the original PAS definition; right quadrant tenderness and percussion tenderness were scored 2 points, others were scored 1 point (Table I). PAS values were calculated for every patient. PAS values equivalent or higher than 6 points were accepted significant for appendicitis.

Statistical analyses were performed with the SPSS Statistics for Windows version 15 package software (SPSS Inc., Chicago, IL, USA). Preoperative, postoperative and total duration of hospitalization of the patients with acute appendicitis, complicated appendicitis and the negative appendectomies were considered with simplex variance analysis. PAS values were considered with leukocyte count, neutrophyl/lymphocyte ratio, C-reactive protein (CRP) values and cutoff points were identified with ROC analysis. The least valuable components of the PAS were identified and exchanged with the most common laboratory findings which were encountered in the appendicitis group, and a new scoring system was generated. Patients were divided into three groups according to age distribution; i) < 6 years, ii) 6-11 years, iii) ≥ 12 years, and the scoring results of the age groups were considered. Continuous variables were analyzed with Student's t test and categorical variables were considered with Chi-squared test. Patient ages and CRP values in the groups were not compatible with the normal distribution therefore these parameters were considered with Mann-Whitney U test. A p-value of less than 0.05 was considered statistically significant for all analysis.

RESULTS

A total of 562 patients were eligible for the study and 350 patients were in group 1, the rest 212 patients were in group 2. Of the patients 321 (57.1%) were male and 241 (42.9%) were female. Age distribution of the patients ranged between 1 to 17 years (median 10 years). Male/female ratios and the ages of the patients in both groups were similar (p>0.05) (Table II).

Preoperative hospitalization time of the acute and complicated cases was similar, whilst clearly prolonged in negative cases (p=0.002). Postoperative and total hospitalization time of the acute and negative cases were similar, but complicated cases had a significantly prolonged postoperative and total hospitalization time (p<0.001) (Table III). The mean hospitalization time of the followed-up patients without surgical exploration was 39.3±28.5 hours.

The mean PAS value of the acute appendicitis was 6.95±1.3, complicated appendicitis was 7.5±1.4, negative appendectomies was 6.1±1.8, and the follow-up patients was 4.05±1.8 respectively. There was a significantly difference between acute, complicated and negative cases in terms of PAS values (p<0.001). PAS value was increased in proportion to the severity of appendicitis (p<0.001). Of the negative explorations 54.8% (n=17) had a PAS value ≥6, and 45.2% (n=14) had a PAS value <6. When the PAS value equivalent or higher than 6 points was presumed appendicitis, diagnostic sensitivity and specificity of the PAS were 88.6% and 72.6 respectively (Table IV, Figure 1).

When the both groups were considered in terms of laboratory findings; leukocyte count, neutrophile count, neutrophile percentage, neutrophile/lymphocyte (N/L) ratio, and CRP values were found to be significantly higher in group 1 (p<0.001) (Table V).

Cutoff points, sensitivity and specificity of the PAS value and laboratory findings were calculated in terms of diagnosing appendicitis (Table VI). N/L ratio was the most sensitive, and neutrophile count was the most specific laboratory finding.

The incidences of the PAS components and laboratory findings were calculated in both groups (Table VII). Of the patients with appendicitis in group 1, 29.1% had fever and 6.2% had migration of the pain to the right lower quadrant, and these parameters provided the least contribution to the diagnosis. Instead of these, with the usage of N/L ratio (high in 81% of the group 1) and CRP (high in 76% of the group 1) values we achieved a second score defined as PAS-2 with a sensitivity of 91.1% and specificity of 64.2 (Figure 2). PAS-2 value was increased in proportion to the severity of appendicitis (p<0.001) (Table VIII). Of the negative explorations, 58% (n=18) had a PAS-2 value ≥6 and 42% (n=13) had a PAS-2 value <6.

In terms of age distribution; the sensitivity of PAS was highest <6 years old, and lowest ≥12years old whilst, the specificity of PAS was highest ≥12 years old, and lowest <6 years old. The sensitivity of PAS-2 was similar <12 years old, the specificity of PAS-2 was highest between 6 to 11 years old and lowest under six years old. Over 6 years of age, the sensitivity of PAS-2 was higher than PAS, but the specificity of the PAS-2 was lower than PAS (Table IX).

Of the appendicitis group 19.8% and of the negative explorations 42% N/L ratio and CRP values were found below the cutoff point. Of the appendicitis group 56.2% and of the negative appendectomies 29%, one of the N/L ratio or CRP values were found to be lower. Of the negative appendectomies 29% (n=9), both the N/L ratio and CRP values found to be high.

Of the patients under 6 years old (n=33) in group 2, five had acute gastroenteritis (AGE), two had upper respiratory tract infection (URTI), one had urinary tract infection (UTI), and four (7.5%) patients were exposed to negative exploration. Of the patients between 6 to 11 years old (n=81) in group 2, two had Familial Mediterranean Fever (FMF), one by one AGE, URTI, UTI, Henoch Schönlein Purpura were encountered, and eleven patients (7.5%) were exposed to negative exploration. Of the patients over 12 years old (n=98) in group 2, two had ovarian cyst, three had AGE, one by one lower respiratory tract infection, FMF, UTI were encountered, and sixteen patients (8.8%) were exposed to negative exploration.

Table I: Pediatric appendicitis score.

Symptoms	Score
Anorexia	1
Fever	1
Nausea-vomiting	1
Migration of the pain to right lower quadrant	1
Leukocytosis (≥12000 / µL)	1
Neutrophilia (≥70%)	1
Right lower quadrant tenderness	2
Percussion tenderness	2

Table II: Demographic data of groups.

Characteristics of groups	Appendicitis (n=350)	Others (n=212)
Male/Female	211 / 139	110 / 102
Mean age (year)	10	10
Diagnosis	Acute appendicitis=224 Complicated appendicitis=126	Negative exploration=31 Follow-up=181

Table III: Duration of hospitalization of the acute, complicated and negative appendectomies.

	Preoperative hospitalization time (hours)	Postoperative hospitalization time (hours)	Total duration of hospitalization (hours)
Acute appendicitis	5.5±5.4	52.4±22.5	58.1±22.6
Complicated appendicitis	4.4±4.2	128.8±72.3	133.7±72.5
Negative appendectomy	8±6.4	60.6±25.2	68.9±25.5

DISCUSSION

Although, appendicitis is the most common situation necessitating urgent surgical exploration in childhood, in modern era diagnostic difficulties still continue. In the literature, either to prevent the unnecessary surgical explorations or to prevent the appendicitis perforation and its morbidity; frequent and close follow-up of suspicious cases , utilizing laboratory results, diagnosing with abdominal ultrasonography or computed tomography, using scoring systems are suggested (1,5,7-9).

Appendicitis scoring systems were previously generated for facilitating appendicitis diagnosis in adults. Samuel M (5) has analyzed these scoring systems, investigated the 4 to 15 years old children, and adapted the scoring system to children in 2002. Pediatric appendicitis score is a simple scoring system depending on patient history, physical examination signs and laboratory results. PAS value is calculated over 10 points and equal or higher than 6 points is presumed most likely appendicitis. In Samuel's study (5) the reported PAS sensitivity was100%, the specificity was 92%, negative appendectomy was 4.9% (36/770), and complicated appendicitis was 29%

Table IV: PAS values of both groups.

PAS values	Appendicitis (n=350)	Others (n=212)
PAS 1-5	40 (11.4%)	154 (72.6%)
PAS 6-10	310 (88.6%)	58 (27.4%)

Table V: Consideration of groups in terms of laboratory results.

Laboratory results	Appendicitis (n=350)	Others (n=212)
Leukocyte count	15.683±5.752 / µL	10.412±5.131 / µL
Neutrophyl percentage	74.7±11%	61.6±14.6%
Neutrophyl count	10.98±4,4 / µL	6.4±4.1 / µL
N/L ratio	6.9±4.5	3.4±3.3
CRP	35 mg/L (1-391 mg/L)	8 mg/L (1-275 mg/L)

Table VI: Cutoff point, sensitivity, and specificity of PAS and laboratory signs.

	Cutoff point	Sensitivity (%)	Specificity (%)
PAS	6	88.6	72.6
Leukocyte count	11850 / µL	76	71
Neutrophyl percentage	65.95%	81	61.3
Neutrophyl count	8.97 / µL	70.3	77.8
N/L ratio	2.96	82	63
CRP	13.5 mg/L	76	60

Table VII: The incidence of PAS components and laboratory signs in both groups.

Components of pediatric appendicitis score	Appendicitis (n=350)		Others (n=212)	
Anorexia	n=226	64.6%	n=110	51.9%
Fever	n=102	29.1%	n=35	16.5%
Nausea-vomiting	n=257	73.4%	n=114	53.8%
Migration of the pain to right lower quadrant	n=22	6.2%	n=8	3.8%
Leukocytosis (≥12000 / µL)	n=261	74.6%	n=61	28.8%
Neutrophilia (≥%70)	n=250	71.4%	n=65	30.7%
Right lower quadrant tenderness	n=349	99.7%	n=194	91.5%
Percussion tenderness	n=347	99.1%	n=74	34.9%
Laboratory signs				
Neutrophyl count	n=246	70.3%	n=47	22.2%
Neutrophyl / lymphocyte ratio	n=284	81.1%	n=79	37.3%
CRP	n=266	76%	n=86	40.6%

(213/734). Recent studies disclosed the sensitivity of PAS 83-97 percentages, and we encountered an 88.6% of sensitivity in our study similar with the literature.

PAS was generated for the patients older than 4 years and it was thought that younger children could not express their complaints exactly and properly (5,2). In contrast, in our study the highest sensitivity of PAS value was encountered within the patients younger than 6 years. Also, the sensitivity of PAS was found to be decreased with age. In the literature, there is not any similar evaluation in terms of changing sensitivity of PAS with age, thus we could not consider this result. In our study, fever and migration of the pain to the right lower quadrant provided the least contribution to the diagnosis, instead of these parameters with using of N/L ratio and CRP values we generated the PAS-2, and we disclosed that age did not affected the sensitivity of PAS-2. While the specificity of PAS was higher within the patients older than 12 years, the specificity of the PAS-2 was found to be higher within the patients aged 6 to 12 years old.

One of the prior aims of all the studies concerning appendicitis is decreasing the probability of negative appendectomies. The reported ratio of negative appendectomy ranges 4% to 13% in the literature (5,7,10), and we encountered a ratio of 8.1% in this study. We discovered that 45.2% and 42% of the negative appendectomies could be diagnosed correctly with usage of PAS and PAS-2 respectively. In the literature, the usage of N/L ratio with a sensitivity rate of 90.2% is suggested for diagnosing appendicitis (8). In this study the cutoff point of N/L was calculated 2.96, and the sensitivity of N/L was found relatively lower than the literature (82%). In another study, the value of CRP was explored in terms of diagnosing appendicitis, and similar to our study the sensitivity of CRP was found 76.5% (4). When we explored the laboratory results of the patients with negative appendectomies, we discovered that both the N/L ratio and CRP values were low within 42% (13/31) of the cases; additionally one of these two values was low within 29%

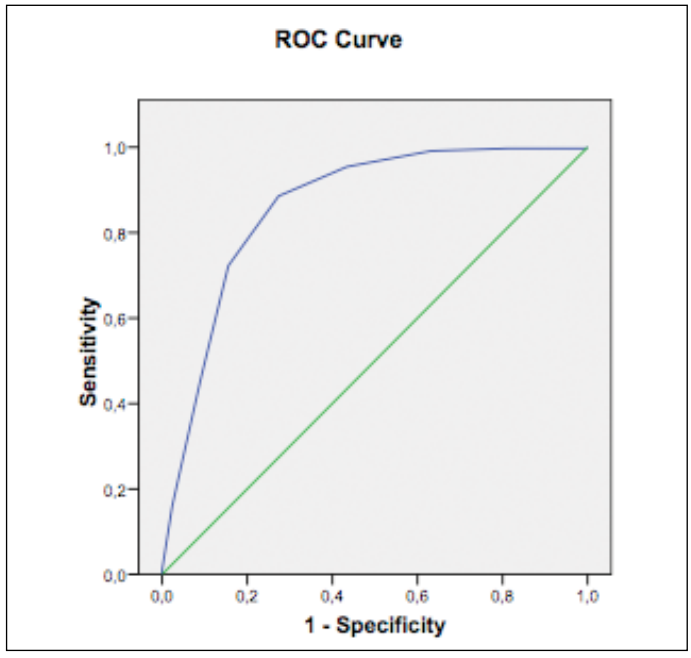

Figure 1: PAS (88.6% sensitivity, 72.6% specificity; area under curve, 0.863; p<0.001), ROC (Receiver Operating Characteristic) curve.

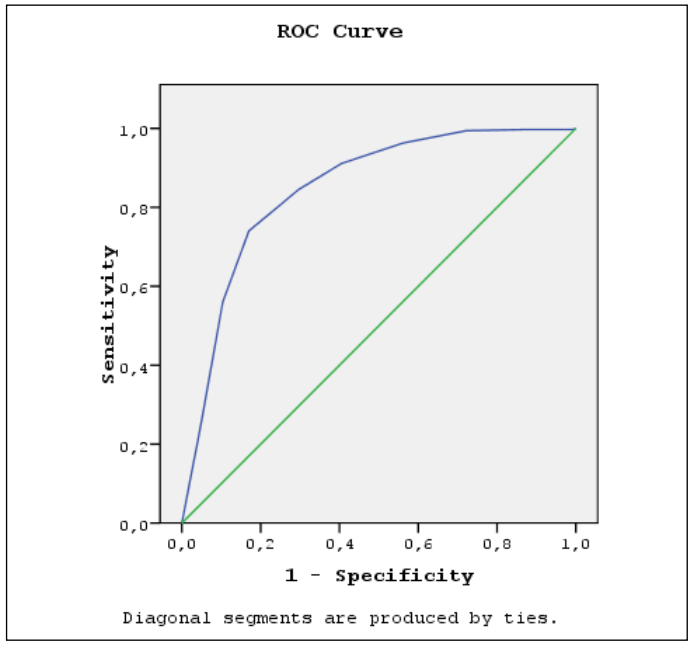

Figure 2: PAS 2 (91.1% sensitivity, 64.2% specificity; area under curve, 0.848; p<0.001), ROC curve.

Table VIII: Distribution of PAS-2 values in groups.

PAS-2 results	Appendicitis (n=350)	Others (n=212)
PAS 1-5	31 (8.9%)	136 (64.2%)
PAS 6-10	319 (91.1%)	76 (35.8%)

Table IX: PAS and PAS-2 values of age groups.

Age	Score	Mean Score	≥6	<6	Sensitivity	Specificity
<6 years (n=82)	PAS	6.5±2	74.4%	25.6%	95.9%	57.6%
	PAS2	7.46±2.1	73.2%	26.8%	91.8%	54.5%
6-11 years (n=217)	PAS	6.2±2	66.8%	33.2%	89.7%	71.6%
	PAS2	7.2±2.4	70.5%	29.5%	91.9%	65.4%
≥12 years (n=263)	PAS	5.9±2.1	61.6%	38.4%	85.5%	78.6%
	PAS2	6.9±2.6	73%	27%	90.3%	56.1%

(9/31) of the cases. This result emphasizes that examining N/L ratio and CRP values within suspicious cases may be beneficial to prevent negative appendectomies.

In another point of view, while avoiding negative appendectomies, surgeons may face with increased ratio of complicated appendicitis. This ratio of complicated appendicitis is reported to be 29% to 49% in the literature (5,7,8). Similarly, in this study the complicated appendicitis ratio was 33%. We did not encounter any perforated appendicitis in the preoperative follow-up period. Preoperative duration of hospital stay was similar within both the acute and complicated cases, whilst longer within the negative cases. Of the complicated appendicitis 6.3% (n=8) couldn't diagnosed with PAS, and of the complicated appendicitis 2.4% (n=3) couldn't diagnosed with PAS-2. In terms of laboratory results, both the N/L ratio and CRP value were found to be low within the 9.4% of the acute appendicitis and only one (0.8%) of the complicated appendicitis. In this study, the specificity of the N/L ratio and CRP value in terms of diagnosing appendicitis were low, similar with the literature (5,11,12). After analyzing the results of this study we affirm that it is not possible to diagnose or exclude the diagnosis of appendicitis with only considering laboratory results.

In conclusion, instead of using the PAS parameters of fever and migration of the pain to the right lower quadrant which have the least contribution to the diagnosis in this study, with the use of N/L ratio and CRP value it is possible to increase the sensitivity of PAS in terms of diagnosing appendicitis. The risk of missing complicated appendicitis is extremely low with PAS-2, and also PAS-2 reduces the possibility of negative appendectomy by almost half. Primarily, evaluating the history of the patient and clinical signs are essential to diagnose appendicitis. Furthermore, we advocate considering the N/L ratio and CRP value which may decrease the possibility of negative appendectomies within the suspicious cases.

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